Claims:

1. An assist apparatus for electric-powered power steering apparatus having a torque sensor, assist shaft, worm wheel, worm shaft, elastic force application means and an electric motor, comprising first to fourth bearings and wherein the torque sensor is located around the steering shaft or pinion; the assist shaft is one of the steering shaft, the pinion shaft and a sub-pinion; the worm wheel is fastened around either one of the steering shaft, pinion and sub-pinion; the worm shaft has a worm gear that meshes with the worm wheel; the electric motor comprises a rotating shaft, a rotor that is located on the outer-diameter side of the rotating shaft, and a stator that is located such that it faces the rotor in the radial direction; and the rotating shaft and worm shaft are connected to each other by way of a toothed joint or elastic member, wherein the first bearing supports inside the casing the end section of the rotating shaft on the opposite side from the worm shaft; the second bearing supports inside the casing the portion between the joint, which connects the worm shaft and the rotating shaft, and the rotor; the third bearing supports the end of the worm shaft on the side of the rotating shaft inside the gear housing such that the worm shaft can free tilt within a specified range; and the fourth bearing supports the end of the worm shaft on the opposite side from the rotating shaft inside the

gear housing, wherein a clearance in the radial direction is provided between either the outer peripheral surface of the outer race of the fourth bearing and the inner surface of the gear housing, or between the inner peripheral surface of the inner race of the fourth bearing and the outer peripheral surface of the worm shaft, wherein the elastic-force application means comprises an elastic member having a variable spring constant that can be changed from a low spring constant of 1 N/mm to 20 N/mm to a high spring constant of 180 N/mm or more, and located between the fourth bearing and gear housing, between the fourth bearing and the worm shaft and/or between the gear housing and the worm shaft so as to apply an elastic force corresponding to the radial displacement of the worm shaft, wherein when not driven by the electric motor, the elastic force having a low spring constant applies a pre-load to parts of the toothed surfaces of the worm and worm wheel to bring them into contact; and when driven by the maximum output of the electric motor and the worm shaft is moved in the direction going away from the worm wheel by the reaction force applied to the worm shaft from the worm wheel, with the area of meshing moved just 0.1 mm to 1.0 mm in the radial direction of the worm shaft with respect to when not driven, the elastic force having a high spring constant applies a pre-load to parts of the toothed surfaces of the worm and worm wheel and

brings them into contact, wherein the amount of increase in torque of the assist shaft due to the rise in friction force in the area where the worm shaft meshes with the worm wheel caused by applying an elastic force having a low spring constant to the worm shaft is kept within a range of 0.4 Nm to 5 Nm.

2. The assist apparatus for an electric-powered power steering apparatus described in Claim 1, wherein the total $sum._1$ of the gaps in the radial direction existing inside the second bearing, in the fitting section between the inner race of the second bearing and the rotating shaft, and in the fitting section between the outer race of the second bearing and the inner surface of the casing is less than the total $sum._2$ of the gaps in the radial direction existing inside the third bearing, in the fitting section between the outer race of the third bearing and the inner surface of the gear housing, in the fitting section between the inner race of the third bearing and the worm shaft, and in the connecting section between the worm shaft and the rotating shaft.

3. The assist apparatus for an electric-powered power steering apparatus described in Claim 1, wherein when the amount of displacement in the radial direction of a point on the center axis of the rotating shaft where a 20 N force is applied in the radial direction, to a place on the

rotating shaft that coincides in the axial direction with the second bearing is taken to be x_1, and the amount of displacement in the radial direction of a point on the center axis of the worm shaft where a 20 N force is applied in the radial direction, to a place on the worm shaft that coincides in the axial direction with the third bearing is taken to be x_2, and the displacement in the radial direction of the center axis of the rotating shaft with reference to the center axis of the worm shaft in a part connecting the center axis of the worm shaft with the center axis of the rotating shaft when a 20 N force is applied in the radial direction to the part on the rotating shaft where the worm shaft and rotating shaft are connected is taken to be x_3, $x_1 < (x_2 + x_3)$.

4. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 3, wherein the angle between the worm shaft and rotating shaft when driven by the electric motor is less than the angle between the worm shaft and the rotating shaft when not driven by the electric motor.

5. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 4, wherein the angle between the center axis of the worm shaft and the center axis of the rotating shaft when driven by the electric motor is 10 minutes or less.

6. The assist apparatus for an electric-powered power steering

apparatus described in any of Claims 1 to 5, wherein the third bearing is a deep-groove type ball bearing having a C2 or C3 internal clearance.

7. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 6, wherein the third bearing is a four-point contact type ball bearing.

8. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 7, wherein the balls of at least one of the third and fourth bearings are pre-loaded in the axial direction by a force of 20 N to 200 N.

9. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 8, wherein the connection between the worm shaft and the rotating shaft is located at a position that coincides in the axial direction with the third bearing.

10. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 9, wherein the ends of the worm shaft and the rotating shaft are connected by a spline joint and wherein the displacement in center of both shafts due to clearance in the radial direction of the spline joint is kept within 10 .m to 200 .m.

11. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 10, wherein the ends of the worm

shaft and rotating shaft are connected to each other by a spline joint, and wherein the displacement of the centers of the worm shaft and rotating shaft due to the clearance existing in-row section between the casing which supports the end of the rotating shaft, and the gear housing which supports the end of the worm shaft, is less than the displacement of the center of these shafts due to the clearance in the radial direction existing in the spline joint.

12. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 11, wherein the rotor comprises a permanent magnet and the stator comprises a coil, and wherein a vector-control apparatus changes the magnetic force of the stator.

13. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 12, wherein a controller controls the output of the electric motor according the amount of displacement in the radial direction of the worm shaft.

14. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 13, wherein the amount of displacement in the radial direction of the center axis of the worm shaft at a portion where a 20 N force is applied in the radial direction and where the worm shaft coincides in the axial direction with the second bearing is 5.m

to 200.m.

15. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 14, wherein the force received by the second bearing from the rotating shaft due to the force acting on the area where the worm wheel meshes with the worm shaft when driven by the electric motor is less than the force received by the third bearing from the worm shaft due to the force that acts on this same area of meshing.

16. The assist apparatus for an electric-powered power steering apparatus described in any of Claims 1 to 15, wherein the position of the center in the axial direction of the spline joint between the worm shaft and the rotating shaft is located closer to the third bearing than the position of the center in the axial direction between the second bearing and the third bearing.

17. The assist apparatus for an electric-powered power steering apparatus of any of Claims 1 to 3, wherein the elastic force is applied to the worm shaft from the elastic-force application means located inside the gear housing without by way of the fourth bearing.

18. The assist apparatus for an electric-powered power steering apparatus of Claim 17 above wherein the elastic-force application means comprises a torsion coil spring that is located around the worm shaft.

19. An assist apparatus for an electric-powered power steering apparatus having a torque sensor, assist shaft, worm wheel, worm shaft, and electric motor, and comprising a first bearing and fourth bearing; wherein the torque sensor is located around the steering shaft or pinion; the assist shaft is one of the steering shaft, pinion and a sub-pinion; the worm wheel is fastened to one of the steering shaft, pinion and sub-pinion; the worm shaft is formed with a worm that meshes with the worm wheel; and the electric motor comprises a rotating shaft that is integrated with a part of the worm shaft, a rotor that is located around the outer-diameter side of the rotating shaft, and a stator that is located such that it faces the rotor in the radial direction; wherein the first bearing supports the end of the rotating shaft on the side opposite from the worm shaft inside the casing such that the rotating shaft can tilt freely within a specified range; and the fourth bearing supports the end of the worm shaft on the opposite side from the rotating shaft inside the gear housing; wherein a clearance in the radial direction is provided either between the outer peripheral surface of the outer race of the fourth bearing and the inner surface of the casing, or between the inner peripheral surface of the inner race of the fourth bearing and the outer peripheral surface of the worm shaft or in the interior of the fourth bearing.

20. The assist apparatus for an electric-powered power steering apparatus of Claim 19, wherein a cylindrical member is fastened around the outer peripheral surface of the worm shaft, and worm teeth are formed around the outer peripheral surface of this cylindrical member to mesh with the worm wheel.

21. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 20, wherein the angle between the center axis of the stator and the rotating shaft of the electric motor when driven by the electric motor is less than the angle between the center axis of the stator and the rotating shaft when not driven by the electric motor.

22. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 21, wherein the inner peripheral surface of the inner race of the fourth bearing faces the outer peripheral surface of the worm shaft by way of a clearance or elastic material.

23. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 21, wherein the fourth bearing is a sliding bearing, and wherein the inner peripheral surface of this sliding bearing faces the outer peripheral surface of the worm shaft.

24. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 23, wherein a hole for assembling the

fourth bearing inside the gear housing that supports the fourth bearing is formed in the part of the gear housing that faces the fourth bearing, and this hole is blocked with a cover.

25. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 24, wherein the electric motor uses brushless construction.

26. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 25, wherein a support bushing is provided in part of the casing for supporting the worm shaft before it is installed inside the gear housing.

27. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 26, wherein a pre-load in the axial direction is applied to the balls of at least one of the first and fourth bearings.

28. The assist apparatus for an electric-powered power steering apparatus of any of Claims 19 to 27, wherein the first bearing is a four-point contact type ball bearing.

29. An electric-powered power steering apparatus comprising: a steering shaft having a steering wheel located at its rear end, a pinion that is located at the front end of the steering shaft, a rack whose teeth mesh with

the pinion or a member supported by the pinion, the assist apparatus for an electric-powered power steering apparatus of any of Claims 1 to 28 and a controller for controlling the drive state of the electric motor.

30. An electric-powered power steering apparatus wherein the torque obtained by reducing the output of the electric motor by a worm speed reducer at a magnitude corresponding to the steering torque applied to the steering wheel is applied to the steering shaft, and wherein an elastic-force application means applies an elastic force in the direction toward the worm wheel to an end of the worm shaft or to the bearing for supporting the end of the worm shaft.

31. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means is a pre-load pad that is located inside the gear housing, and a torsion coil spring that is located around this pre-load pad, and wherein this pre-load pad is made of synthetic resin.

32. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means is a pre-load pad that is located inside the gear housing and a torsion coil spring that is located around this pre-load pad, and wherein there is a gap in the axial direction between the surface of the wires of each winding of the torsion coil spring.

33. The electric-powered power steering apparatus of Claim 30,

wherein the elastic-force application means is a pre-load pad that is located inside the gear housing and a torsion coil spring that is located around this pre-load pad, and wherein an arm section is formed on part of the pre-load pad for controlling the displacement of the pre-load pad inside the gear housing before the worm shaft is inserted through a through hole that is formed in the pre-load pad.

34. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means is a pre-load pad that is located inside the gear housing and a torsion coil spring that is located around this pre-load pad, and wherein the area of contact between the outer peripheral surface of the pre-load pad and the torsion coil spring is arc shaped such that the radius of curvature of the part on the outer peripheral surface of the pre-load pad away from the area of contact is less than the radius of curvature of the area of contact.

35. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means is a pre-load pad that is located inside the gear housing and a torsion coil spring that is located around this pre-load pad, and wherein a protruding fitting section is formed on part of the outer peripheral surface of the pre-load pad for preventing the torsion coil spring from falling off from around the pre-load pad.

36. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means is a pre-load pad that is located inside the gear housing, and wherein protrusions are formed at two or more locations on each end in the axial direction of the pre-load pad for controlling displacement in the axial direction of the pre-load pad inside the gear housing.

37. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means has a pre-load pad that is located inside the gear housing, and wherein elastic material is located between the gear housing or a member fixed to the gear housing and the outer peripheral surface of the pre-load pad for preventing the pre-load pad from turning inside the gear housing.

38. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means has a pre-load pad that is located inside the gear housing, and wherein a through hole is formed in part of the pre-load pad for inserting the tip end of the worm shaft and a tapered surface is formed on part of the pre-load pad for guiding part of the worm shaft into the through hole.

39. The electric-powered power steering apparatus of Claim 30, wherein the elastic-force application means has a pre-load pad that is

located inside the gear housing, and wherein a tapered surface is formed on part of the pre-load pad or bearing for guiding the worm shaft inside the pre-load pad or worm shaft, and wherein the diameter of the opening of this tapered surface is greater than the diameter of the part on the warm shaft that is inserted into this opening by 0.5 mm or more.